Econ 311: Behavioral and Experimental Economics

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Prospect Theory

An Overview of Prospect Theory

- Prospect theory originally laid out by Kahneman and Tversky (1979)
- The *four-fold pattern*
  1. Decision value determined by reference point
  2. Loss aversion
  3. Risk averse over gains and risk seeking over losses
  4. Non-linear probability weighting

Reference Dependence: Motivating Example

- Consider the following two decision problems:
  - Problem 1: Win \$900 for certain OR 90% chance of winning \$1000
    - Which option would you choose?
  - Problem 2: Lose \$900 for certain OR 90% chance of losing \$1000
    - Which option would you choose?
- Most people choose the certain option when only gains are possible but the risky option when only losses are possible
- What does expect utility theory say you should do in these problems?
  - If you are risk averse, you should choose certain option in both

Motivating Example, cont

- An even starker pairing:
  - Problem 3: You have been given $1000. You are now asked to choose between these two options: 50% chance of winning another $1000 OR winning $500 for certain
    - Which option would you choose?
  - Problem 4: You have been given $2000. You are now asked to choose between these two options: 50% chance of losing $1000 OR losing $500 for certain
    - Which option would you choose?
- People tend to choose certain option in Problem 3 but risky option in Problem 4
- What does expect utility theory say you should do in these problems?
  - According to expected utility theory, these are *exactly the same problem*
    - In both cases, total winnings are either $1500 for certain or coin flip for $1000 vs $2000
  - Key difference not captured by expected utility: your starting point of wealth before the gamble ($1000 vs $2000)

What is Reference Dependence?

- Reference dependence: when people evaluate alternatives by comparing them to a *reference point*
- Where could reference point come from?
  - Current wealth level
  - Aspirational wealth level
  - Expected outcome
  - Social comparison
- So which one is reference point?
  - Depends on context
  - Theory is still weak here: determination of reference point gives and extra *degree of freedom* to the model

Biological Roots of Reference Dependence

"Our perceptual apparatus is attuned to the evaluation of changes or differences rather than the the evaluation of absolute magnitudes... The past and present context of experience defines an adaptation level, or reference point, and stimuli are perceived in relation to this reference point." – Kahneman and Tversky (1979)

- Many perceptual systems in the brain evaluate *differences* rather than absolute values
  - For example, the visual system
  - Weber-Fechner law: The just-noticeable difference between two stimuli is proportional to the stimulus magnitude
  - Retinal cells respond to differences in light intensity

Reference-Dependent Utility

- Suppose consumption is evaluated relative to some reference point c^r
- Then utility of consumption c depends on c^r as well
- One useful formulation: utility depends on the difference between current consumption and reference level

$$u(c|c^r) = v(c - c^r)$$

- In general, more complex formulations are possible

Loss Aversion: Motivation

"A salient characteristic of attitudes to changes in welfare is that **losses loom larger than gains**. The aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount." – Kahneman and Tversky (1979)

- That is, people attach more of a utility change to an decrease in consumption relative to the reference point than to an increase in consumption of the same magnitude
- Biological basis: Different brain regions are used to value losses and gains

Incorporating Loss Aversion into the Theory

- We want losses to hurt more than gains of the same size feel good
- One way to get this feature
  - Recall $u(c|c^r) = v(c - c^r)$
  - Assume $v(0) = 0$
  - Let $v(-x) = -\lambda v(x)$ for some $\lambda > 1$
  - So then

$$u(c|c^r) = \begin{cases} v(|c - c^r|) & \text{if } c - c^r > 0 \\ -\lambda v(|c - c^r|) & \text{if } c - c^r < 0 \end{cases}$$

- What does this utility function look like?

Loss Aversion is Not Risk Aversion

- *Thinking Fast and Slow* is a bit imprecise about this point
- Turning down a positive expected value lottery is completely consistent with having *risk*-averse expected utility preferences
  - Eg prefer not to take coin flip for +\$150 or -\$100
- What is *not* consistent with classic expected utility is for the *framing* of the problem (and hence the reference point) to affect the apparent risk aversion

Evidence for Loss Aversion

- Kahneman, Knetsch, and Thaler (1991)
- Undergraduates participate sequentially in 11 markets for goods like pens and mugs
- Half of subjects endowed with item
- Value of item for buyer and sellers gathered through price lists
- Items transacted at market prices (not random price as we did)
- Results
  - Median WTA (seller stated price) 2-3 times higher than median WTP (buyer stated price)
  - Interpretation: Sellers' stated price is higher because it is relative to endowment of having the item
  - We call this the *willingness to pay vs willingness to accept gap*

Motivation: Risk-Seeking in Losses

- In our examples of problem 1 and problem 2 earlier, we saw that people appear to be risk-seeking when they are in the loss domain (below the reference point)
- Psychological motivation: people become risk averse in loss domain to increase likelihood of getting back to reference point
- However, tend to be risk-averse when gains are involved
- We sometimes call the combination of these features *diminishing sensitivity* because the decreasing marginal impact of increasing a gain or loss farther from reference point

Incorporating this into the Theory

- Recall that risk-averse preferences require $v(x)$ to be concave
  - Eg, $v(x) = x^{\alpha}$ for $\alpha \in [0, 1]$ when $x > 0$
- Conversely, risk-seeking preferences require $v(x)$ to be convex
  - Eg, $v(x) = x^{\alpha}$ for $\alpha > 1$ when $x > 0$
  - But when $x < 0$ we get convexity by $\alpha \in [0, 1]$
- Utility is then

$$u(c|c^r) = \begin{cases} (|c - c^r|)^{\alpha} & \text{if } c - c^r > 0 \\ -\lambda(|c - c^r|)^{\alpha} & \text{if } c - c^r < 0 \end{cases}$$

Motivation: Probability Weighting

- Expected utility requires that probabilities enter linearly into utility function, ie:

$$U(A) = pu(x) + (1 - p)u(y)$$

  for outcomes x and y
- This came from independence axiom
- We saw last time that people's preferences may violate independence
- How can we incorporate this violation into a new theory of utility?
  - One possibility: non-linear probability weighting
  - That is, the *decision weight* of an outcome is a non-linear function of the probability of that outcome
  - Note: not saying that people necessarily mis-perceive probabilities

Formalizing Probability Weighting

- We let utility of a gamble A by given by

$$U(A) = \pi(p)u(x) + \pi(1-p)u(y)$$

- $\pi : [0,1] \to [0,1]$ is the *probability weighting function*
- One popular formulation:

$$\pi(p) = \frac{p^\gamma}{p^\gamma + (1-p)^\gamma}$$

  - Overweights low probabilities and underweights high probabilities
  - Note if $\gamma = 1$, $\pi(p) = p$

- What does the probability weighting function look like?

Prospect Theory: The Whole Theory

- Let a gamble $A = (p_i, c_i)_{i=1}^{N}$
- Utility of a gamble A is given by

$$U(A) = \sum_{i=1}^{N} \pi(p_i) u(c_i | c^r)$$

where

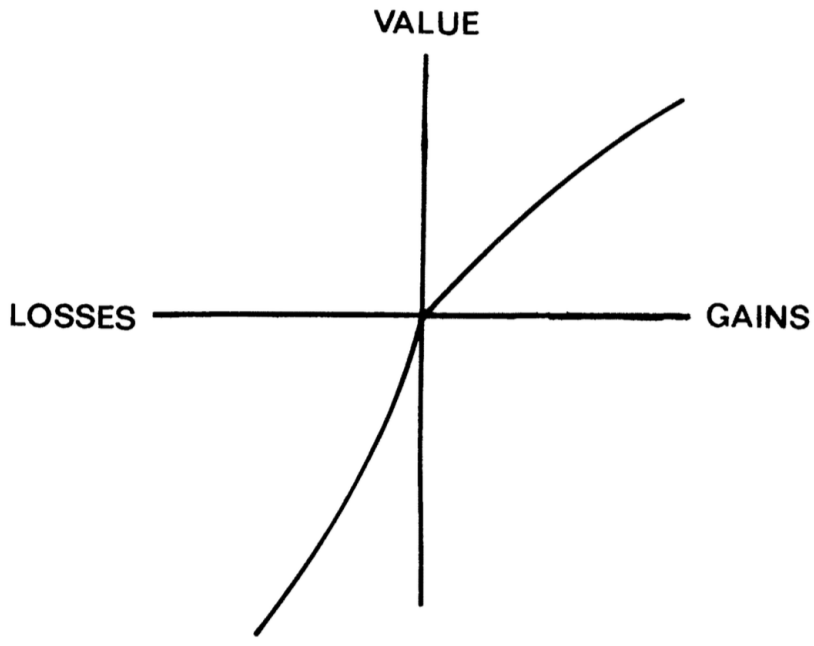
$$u(c|c^r) = \begin{cases} (|c - c^r|)^{\alpha} & \text{if } c - c^r > 0 \\ -\lambda(|c - c^r|)^{\alpha} & \text{if } c - c^r < 0 \end{cases}$$

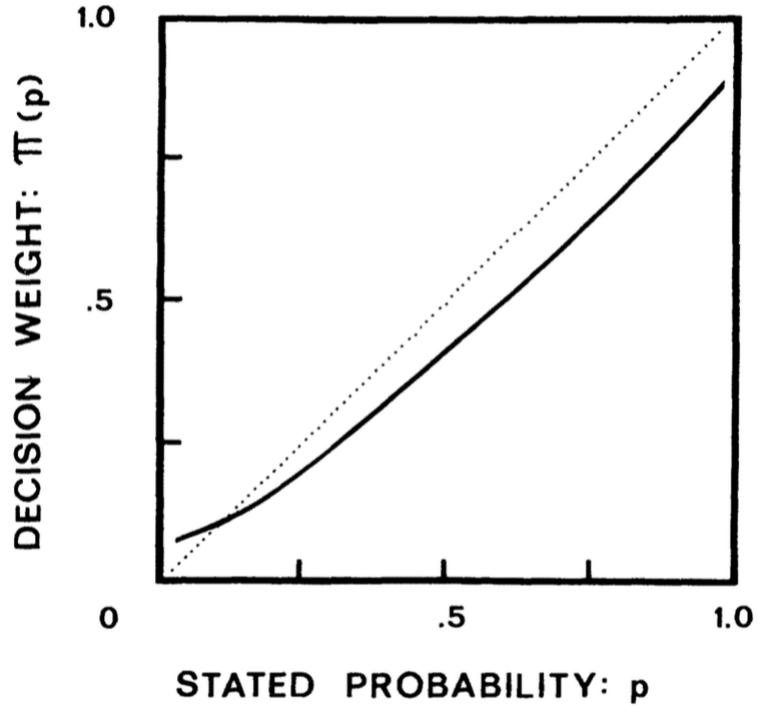
and

$$\pi(p) = \frac{p^{\gamma}}{p^{\gamma} + (1-p)^{\gamma}}$$

- This incorporates all parts of the four-fold pattern:
  1. Decision value determined by reference point
  2. Loss aversion
  3. Risk averse over gains and risk seeking over losses
  4. Non-linear probability weighting

Prospect Theory in Two Pictures





Source: Kahneman and Tversky (1979)

The Endowment Effect

Motivating Example

- Professor A likes to collect wine
- He will not pay more than $35 for a bottle
- Once he gets a bottle, he will not sell it for less than $100
- So, for a price between $35 and $100, will neither sell nor buy
- What is going on?
  - Once he obtains the bottle, its value goes up
  - This phenomenon is the *endowment effect*: owning an item changes its apparent value to the owner
  - Explanation: prospect theory
    - Before owning the bottle, reference point is not having it
    - Once he owns the bottle, having it becomes the reference point
    - Because of loss aversion, losing a bottle hurts more than gaining one feels good

The Classic Experiment

- Undergraduates participate sequentially in 11 markets for goods like pens and mugs
- Half of subjects randomly endowed with item
- Value of item for buyer and sellers gathered through price lists
  - Buyers express *willingness to pay* (WTP) for items
  - Sellers express *willingness to accept* (WTA) to give up items
- Items transacted at market prices (not random price as we did)

Source: Kahneman, Knetsch, and Thaler (1991)

Results

- What relationship should we expect between WTP and WTA?
  - Items were distributed randomly, ie independent of student's actual value of item
  - So average value among sellers should be same as average value among buyers in expectation
  - That is, we expect WTP=WTA
- Results
  - Median WTA (seller stated price) 2-3 times higher than median WTP (buyer stated price)
  - Interpretation: Sellers' stated price is higher because they are endowed with the items, and this increases their value
  - We call this the *willingness to pay vs willingness to accept gap*

Source: Kahneman, Knetsch, and Thaler (1991)

When Does the Endowment Effect Occur?

- List (2003): Traders
  - Inexperienced traders demonstrate endowment effect
  - Experienced traders do not, even with goods they don't trade regularly
- Bertrain, Mullainathan, and Shafir (2004): The poor
  - Poor individuals are essentially always below their reference point
  - Thus, even though they have prospect theory preferences, they never demonstrate loss aversion because they are always in the loss domain